COMMONWEALTH of VIRGINIA

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June 07, 2010

RE: Total Maximum Daily Load modifications for the wasteload allocation in the benthic TMDL for Twittys Creek, a tributary to the Roanoke Creek in the Middle Roanoke River Basin.

The purpose of this memo is to public notice the intent to submit for EPA approval an amendment to the waste load allocation for the benthic TMDL developed for the Twittys Creek in Charlotte County, VA. EPA Region III approved the benthic TMDL addressing an aquatic life use impairment for the Twittys Creek on 09/30/2004. The listed segment, which is about 7.25 miles in length, begins at the former WestPoint Stevens (permit terminated) textile manufacturing plant and extends downstream to the confluence of Twittys Creek with Roanoke Creek.

Permit Details

DEQ has received a request to expand the design flow for Drakes Branch WWTP (VA0084433) from 80,000 GPD to 400,000 GPD. VA0084433 is located in the Twittys watershed and discharges into Twittys Creek. The existing wasteload allocation would accommodate 400,000 GPD at a permitted TSS concentration of 30 mg/L. The wasteload allocation for this facility would be 18.3 ton/yr, or an increase of 14.7 ton/yr. The addition of this WLA will be from the terminated Westpoint Stevens wasteload allocation, 16.8 ton/yr, which has been transferred to future growth. The adjustment to future growth will result in no change to the original TMDL equation.

Additionally, DEQ has received registration statements from Douglas Auto Parts and Service (VAR051752), Tucker Timber Products, Inc. (VAR051513), and Smurfit-Stone Container Corporation (VAR050592) to renew their general permits for stormwater. These industrial stormwater facilities predate the TMDL development, and were overlooked. The run-off value used was 72.54 (cm/yr). VAR051752, VAR051513, and VAR050592 are located in the Twittys Creek watershed and discharge respectively into an unnamed tributary, UT, to Twittys Creek, an UT to Bentleys Branch which drains into Twittys Creek, and an UT to Bentleys Branch which drains into Twittys Creek. The wasteload allocation would accommodate the run-off value of 72.54 (cm/yr) at a permitted bench mark for TSS concentration of 100 mg/l. The wasteload allocations for VAR051752 would be 3.6 ton/year, VAR051513 would be 16.2 ton/yr, and VAR050592 would be 10.5 ton/yr. The addition of the WLA for these three facilities will be taken from the LA portion of the TMDL, due to the fact that these facilities predate the original TMDL development and would have otherwise been incorporated that way initially. The corrections result in a change to the TMDL equation of 3.4% from the original WLA or LA.

Additionally, DEQ proposes adding a construction load of 1% of the TMDL to account for any construction permits which may need to be issued in the watershed. This wasteload allocation would be 8.9 tons/year. The addition of the WLA (39.2 tons/year) for the three facilities and for construction will

be taken from the LA portion of the TMDL, due to the fact that these facilities were preexisting, and were not accounted for in the original TMDL.

Changes to the WLA value would be 4.4% of the TMDL (39.2 ton/yr WLA increase as a percent of 890.1 ton/yr), resulting in the need for an amendment to the original TMDL. Updating the WLA table in the Twittys Creek benthic TMDL in accordance with this amendment will not cause a water quality violation. Due to the significant level of changes to the TMDL equation, an amendment to the TMDL will be required, and following public participation guidance, this public notice will be made for the changes, followed by a 30 day public comment period, during which requests for public meeting will be considered.

TMDL Revisions
These changes affect the following tables, figures and text.

Text of Executive Summary (p E-1): Impairment Listing

Text of Executive Summary (p E-5): TMDL Allocation

Text of Executive Summary, Table E-1 (pE-6): Sediment TMDL for Twittys Creek (tons/year)

Text of Executive Summary, Table E-2 (pE-6): Recommended TMDL Allocations for Twittys Creek

Text of Section 1.2 (p1-2): Impairment Listing

Text of Section 2.2 (p2-9): Permitted Discharge Facilities

Table 2-5 (p2-9): Permitted Discharge Facilities in the Twittys Creek Watershed

Figure 2-4 (p2-10): Location of Permitted Discharge Facilities in Twittys Creek

Text of Section 2.4 (p2-11): Overview of Twittys Creek Watershed

Figure 2-6 (p2-14): Overview of the Twittys Creek Watershed

Text of Section 3.2.5 (p3-14): Special Monitoring Study

Text of Section 3.3 (p3-18): Discharge Monitoring reports (omitted any reference to WestPoint Stevens)

Figure 3-16 (p3-23): Westpoint Stevens – Ammonia (Permit Terminated)

Figure 3-17 (p3-23): Westpoint Stevens – BOD5 (Permit Terminated)

Figure 3-18 (p3-24): Westpoint Stevens – CL2 Minimum Concentration (Permit Terminated)

Figure 3-19 (p3-24): Westpoint Stevens – Chemical Oxygen Demand (Permit Terminated)

Figure 3-20 (p3-25): Westpoint Stevens – Dissolved Oxygen (Permit Terminated)

Figure 3-21 (p3-25): Westpoint Stevens – pH (Permit Terminated)

Figure 3-22 (p3-26): Westpoint Stevens – Total Suspended Solids (Permit Terminated)

Text Section 4.1 (p4-1): Organics

Text of Section 4.5 (p 4-4): Toxics

Text of Section 4.6 (p4-5): Stressor Identification Summary

Text 6.1.2 (p6-2): Point Sources

Text section 6.2.2 (p6-4): Point Source Loadings

Table 6-1 (p6-4): Point Source Loadings

Table 6-7 (p6-14): Twittys Creek Average Annual Sediment Loadings (tons/yr)

Table 7-1 (p7-2): Recommended Wasteload Allocations for Twittys Creek

Table 7-2 (p7-3): Recommended Load Allocations for Twittys Creek

Table 7-3 (p7-3): Sediment TMDL for Twittys Creek (tons/year)

Table 7-4 (p7-4): Recommended TMDL Allocations for Twittys Creek

Text from Section 7.3 (p7-5): Consideration of Critical Conditions

Table 8-1 (p8-3): Recommended Stage 1 TMDL Allocations for Twittys Creek

In accordance with EPA's August 2003 letter to VADEQ, VADEQ hereby makes public notice of the proposed amendment. If you have any questions, please contact Paula Nash, BRRO-L TMDL coordinator, (434) 582-6216 or Dave Lazarus at (804) 698-4299.

Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. Twittys Creek was included on Virginia's 2002 303(d) TMDL Priority List and Report (DEQ, 2002) because of violations of the General Standard (benthic impairment). Twittys Creek is located in the south central region of Virginia in Charlotte County (Figure 1-1). It is a tributary of the Roanoke Creek in the Middle Roanoke River Basin (Hydrologic Unit 03010102).

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Bioassessments of the benthic macroinvertebrate community of Twittys Creek were performed by DEQ using the EPA Rapid Bioassessment Protocols. Results of bioassessments indicated a moderately impaired benthic community at two monitoring stations on the creek (Stations ATWT003.36 and ATWT006.40). Therefore, since the creek only partially supports the designated aquatic life use, the General Standard for the creek is being violated. As a result, the creek was included on the 303(d) list. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

The listed segment, which is about 7.25 miles in length, begins at the former WestPoint Stevens (permit terminated) textile manufacturing plant discharge and extends downstream to the confluence of Twittys Creek with Roanoke Creek. Station ATWT006.40 is located downstream of the WestPoint Stevens (permit terminated) plant at the Route 47 Bridge. Station ATWT003.36 is located further downstream at the Route 642 Bridge, below the Drakes Branch Municipal Wastewater Treatment Plant.

Watershed Characterization and Environmental Monitoring

The Twittys Creek watershed is approximately 19,760 acres. Forested lands (82.6%) represent the dominant land use in the watershed. Agricultural lands (8.5%), developed lands (1.0%), and transitional lands (1.8%) are also present. The watershed is part of the Piedmont ecoregion which comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. The majority of the soils in the watershed are comprised of the Georgeville-Nason-Lignum soils series. Georgeville-Nason-Lignum soils are gently sloping to steep, very deep, well-drained, moderately permeable soils characterized as the type 'B' hydrologic soils group.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) that is impacting the benthic community of Twittys Creek. Available monitoring data included biological assessments, water quality monitoring data, and Discharge Monitoring Reports (DMR) for permitted facilities in the watershed. Biological monitoring data from 1990 to 2002 were analyzed. Instream water quality conditions were assessed primarily based on results from a diurnal monitoring study, field data collected during biological monitoring surveys, toxicity testing, and a special monitoring study conducted by DEQ. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the wastewater treatment facilities in the watershed.

Stressor Identification

The primary stressor to Twittys Creek was determined based on evaluations of candidate stressors that potentially could be impacting the creek. The 303(d) fact sheet indicated "siltation from municipal and industrial point sources" as a possible source of the impairment to the creek. Therefore, sediment was evaluated as a candidate stressor along with other typical stressors including organic matter, nutrients, pH, temperature, and toxics. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed.

Although sedimentation problems were initially attributed to point sources, an evaluation of recent DMR data indicate that both treatment plants are in compliance for total suspended solids and do not appear to contribute a significant solids loading at this time. Rather, sedimentation problems appear to originate mainly from non-point sources in the watershed, including runoff from the Town of Drakes Branch. Non-point sources have contributed to erosion problems, loss of instream habitat, and substrate conditions that are not conducive to a healthy benthic invertebrate assemblage. The predominance of sand and other sediment particles in the substrate is detrimental to many invertebrate taxa, and is likely responsible for the poor condition of the benthic assemblage.

Improvement of the benthic invertebrate community in Twittys Creek is dependent upon reducing non-point source sediment loading to the creek as well as managing the uncontrolled stormwater runoff that leads to streambank erosion and sedimentation problems. These measures should serve to improve benthic habitat and subsequently restore invertebrate populations in the creek. Therefore, a sediment TMDL was developed for Twittys Creek.

Reference Watershed Approach

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for Twittys Creek.

The watershed draining to the DEQ biomonitoring station at river mile 8.59 on Twittys Creek was selected as the reference watershed for the Twittys Creek TMDL development. Reduction of sediment loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for Twittys Creek.

Sediment Loading Determination

Sediment sources within the Twittys Creek watershed include both point and non-point sources. Point sources include solids loading from permitted discharge facilities. Non-point sources include sediment derived from the erosion of lands present throughout the watershed and the erosion of stream banks within Twittys Creek.

Sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Twittys Creek. Sediment loadings from land erosion were determined using Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1990 to 2002 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of Twittys Creek. Average annual sediment loads were computed for each land source based on the 12 year simulation period. In addition, average annual sediment loads from instream bank erosion and point sources were determined. Point source loadings were computed based on the permitted discharge loading rate for total suspended solids. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al (2003).

Under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Twittys Creek reference watershed is smaller than the impaired watershed, reference watershed parameters were adjusted to reflect the size of the impaired watershed. Sediment loadings computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Sediment TMDL allocations for Twittys creek were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Sediment Load of the Adjusted Reference Watershed

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of sediment loadings. An explicit margin of safety of 10% was used for Twittys Creek.

The total wasteload allocated to the WestPoint Stevens and Town of Drakes Branch wastewater treatment facilities was based on the permitted discharge loading rate for total suspended solids for the facility. WestPoint Stevens terminated their permit on April 15, 2005 at which time their wasteload allocation became future growth. The wasteload allocations for Douglas Auto Parts and Service, Tucker Timber Products, Inc. and Smurfit-Stone Container Corporation was based on the permitted stormwater benchmark for total suspended solids. A construction wasteload is being added to account for new permits that may be issued in the watershed. The wasteload allocation for these stormwater facilities and construction will be subtracted from the load allocation due to the fact that these facilities pre-dated the TMDL development. Load allocations for non-point sources were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 28%, the sediment TMDL endpoint is achieved. The TMDL for Twittys Creek is presented in Table E-1 and the recommended TMDL allocations and the percent reduction required for all watershed sources are presented in Table E-2.0

Table E-1: Sediment TMDL for Twittys Creek (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
890.1	741.5	59.6*	89.0

*Note: Includes 2.1 tons/yr future growth remaining from WestPoint Stevens' terminated permit. 14.7 tons/yr of WestPoint Stevens WLA was transferred to Drakes Branch STP to accommodate their expansion from 80,000 gpd to 400,000 gpd. Existing stormwater and construction waste loads were transferred from the LA.

Table E-2: Recommended TMDL Allocations for Twittys Creek

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	61.0	61.0	0
	Evergreen Forest	31.5	31.5	0
	Mixed Forest	25.9	25.9	0
	Pasture/Hay	354.6	247.6	30
	Row Crop	142.0	99.2	30
	Low Intensity Residential	0.7	0.5	30
	Commercial/Industrial	15.7	11.0	30
	Open Water	0.0	0.0	0
	Woody Wetlands	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
	Transitional	315.8	208.7**	41
Instream Erosion	-	80.5	56.2	30
Point Sources	-	59.6	59.6*	0
Total		1087.3	801.1	26

*Includes 2.1 tons/yr future growth. **Existing stormwater and Constructinon permits were subtracted from the transitional land use.

Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency (EPA)'s Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to better develop and regulate a more effective TMDL process. The role of DEQ is to act as a lead agency for the development of statewide TMDLs. DEQ focuses its efforts on all aspects of pollution reduction and prevention to the state waters. DEQ ensures compliance with the Clean Water Act and the Water Quality Planning Act, as well as encourages public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs on a statewide level through the use of grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits from industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (DEQ, 2001a).

As required by the Clean Water Act, Virginia DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) in violation and the potential

source(s) of each pollutant. This list is commonly referred to as the 303(d) list. The Water Quality Monitoring Information and Restoration Act was passed in 1997 by the Virginia General Assembly to guide DEQ in creating and implementing TMDLs for the state waters on the 303(d) list (DEQ, 2001a). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

Twittys Creek was initially included on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report (DEQ, 1998) and subsequently included on Virginia's 2002 303(d) Report on Impaired Waters (DEQ, 2002) because of water quality violations of the General Standard (benthic impairment). Biological assessments conducted at two DEQ monitoring stations on the creek (Stations ATWT003.36 and ATWT006.40) indicated a moderately impaired benthic macroinvertebrate community resulting in the 303(d) listing.

Twittys Creek is located in the south central region of Virginia in Charlotte County (Figure 1-1). It is a tributary of Roanoke Creek in the Middle Roanoke River Basin (Hydrologic Unit 03010102). The listed segment, which is about 7.25 miles in length, begins at the former WestPoint Stevens (permit terminated) textile manufacturing plant and extends downstream to the confluence of Twittys Creek with Roanoke Creek. A map of the listed segment for Twittys Creek is displayed in Figure 1-2.

2.2 Permitted Discharge Facilities

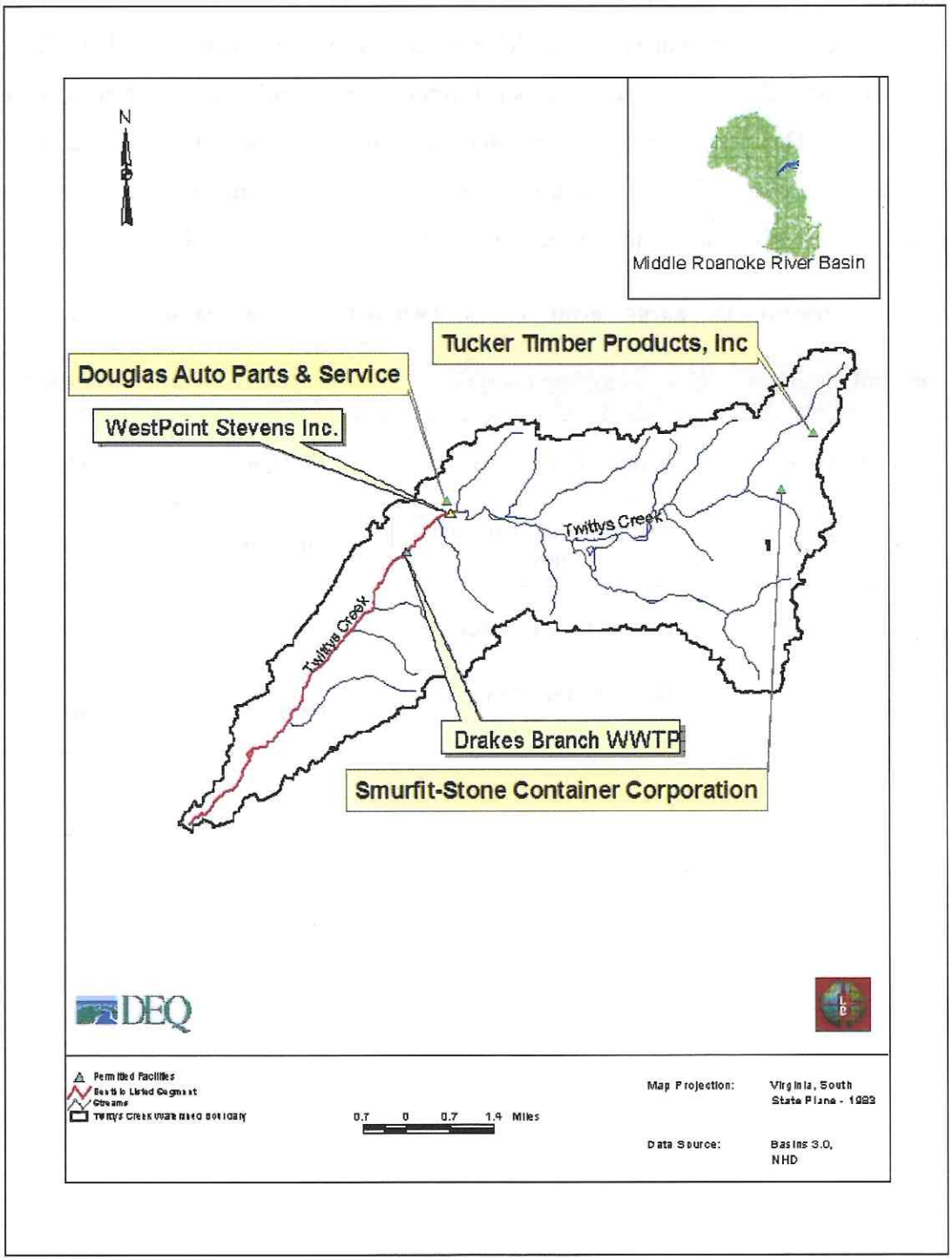
There are four permitted facilities in the watershed that discharge into Twittys creek; these are the Town of Drakes Branch Municipal Wastewater Treatment Plant, Douglas Auto Parts and Service, Tucker Timber Products, Inc., and Smurfit-Stone Container Corporation . There is a construction wasteload available for permitted construction that may need to be issued. Facility permit numbers, design flows, and status are presented in Table 2-5. A map of the permitted facilities is presented in Figure 2-4.

Table 2-5: Permitted Discharge Facilities in the Twittys Creek Watershed

Permit Number	Facility Name	Design Flow (gpd)[a]	Status
VA0084433	Drakes Branch WWTP	400,000	Active
VAR051752	Douglas Auto Parts and Service	Stormwater	Active
VAR051513	Tucker Timer Products, Inc	Stormwater	Active
VAR050592	Smurfit-Stone Container Corporation	Stormwater	Active
	Construction Permits		

a: Gallons per day
b: Maximum 30 day average flow

Figure 2-4: Location of Permitted Discharge Facilities in Twittys Creek



2.3 DEQ Monitoring Stations

DEQ has several monitoring stations on Twittys Creek which are used for biological and ambient water quality monitoring. A summary list of the DEQ monitoring stations located in Twittys Creek watershed is presented in Table 2-6 and station locations are presented in Figure 2-5. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek.

Table2-6: Summary of DEQ Monitoring Stations

Station Id	Station Type	Period Of Record	Note
ATWT009.63	Ambient water quality	1995	
ATWT008.59	Biological monitoring	2002	New reference station
ATWT007.24	Biological monitoring	1990 – 1997	Old reference station
ATWT006.40	Biological monitoring	1990 – 1997, 2002	Recovery station
ATWT003.36	Biological monitoring	1990 – 1997, 2002	Recovery station
ATWT000.32	Ambient water quality	2003	
ARES001.30	Ambient water quality	2003	Station located on the Reeses Creek tributary

Stations ATWT003.36 and ATWT006.40 are the biological monitoring stations on the creek that are impaired based on DEQ bioassessments. Stations ATWT007.24 and ATWT008.59 are biological monitoring stations that were used as non-impaired reference stations for bioassessments. Stations ATWT000.32, ATWT009.63, and ARES001.30 represent additional water quality sampling stations. A detailed discussion of environmental monitoring data is presented in Section 3.0.

2.4 Overview of Twittys Creek Watershed

Forested lands represent the dominant land use (83%) in the Twittys Creek watershed. There are four permitted discharge facilities, Town of Drakes Branch WWTP, Douglas Auto Parts and Service, Tucker Timber Products, Inc, Smurfit-Stone Container Corporation, and a construction wasteload, and seven DEQ monitoring stations in the watershed. The land use and the location of the permitted discharge facilities and monitoring stations are shown in relation to the benthic impairment segment in the

summary map provided in Figure 2-6. Station ATWT006.40 is located downstream of the WestPoint Stevens (permit terminated) plant at the Route 47 Bridge. Station ATWT003.36 is located further downstream at the Route 642 Bridge, below the Drakes Branch Municipal Wastewater Treatment Plant.

Figure 2-5: DEQ Monitoring Stations in the Twittys Creek Watershed

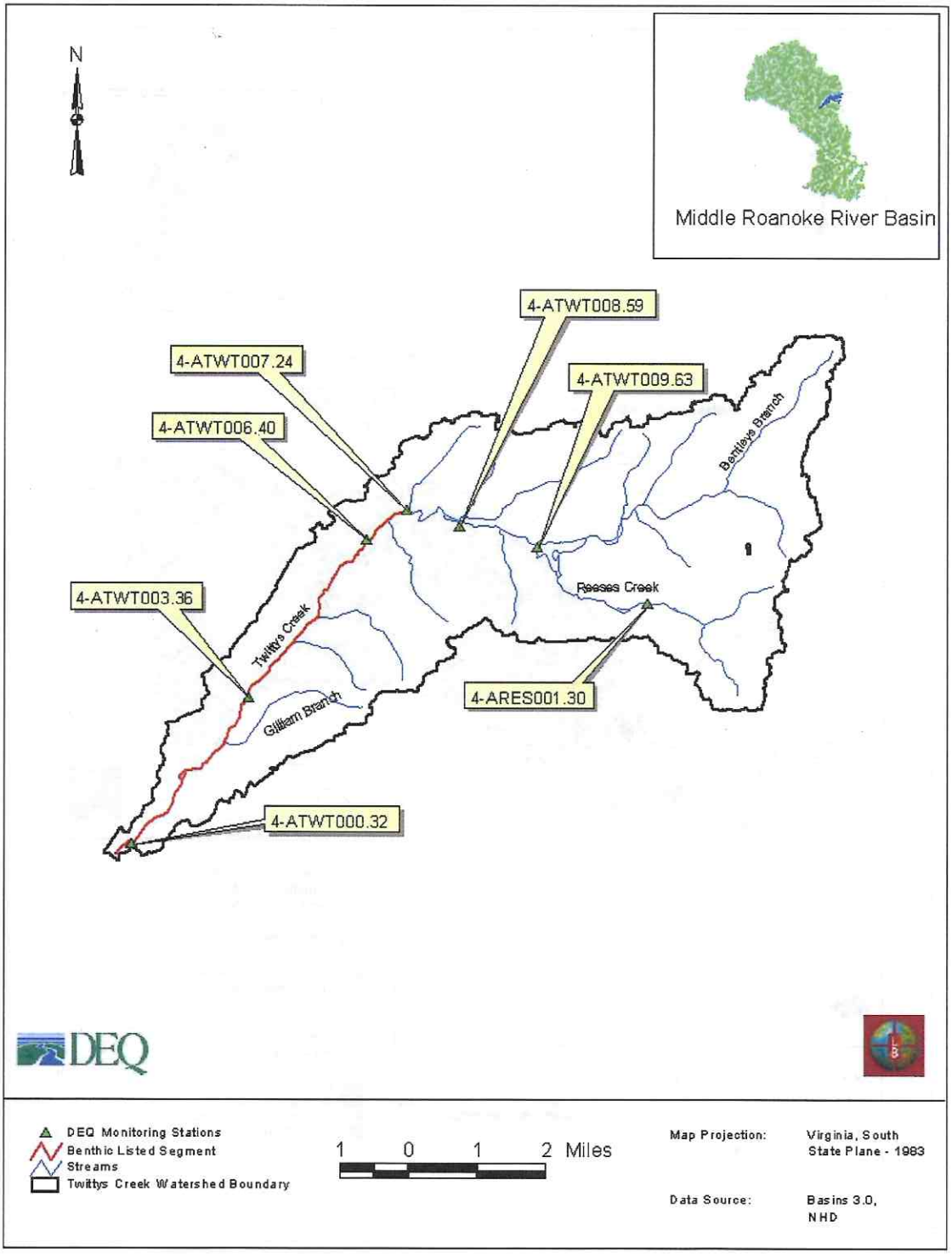
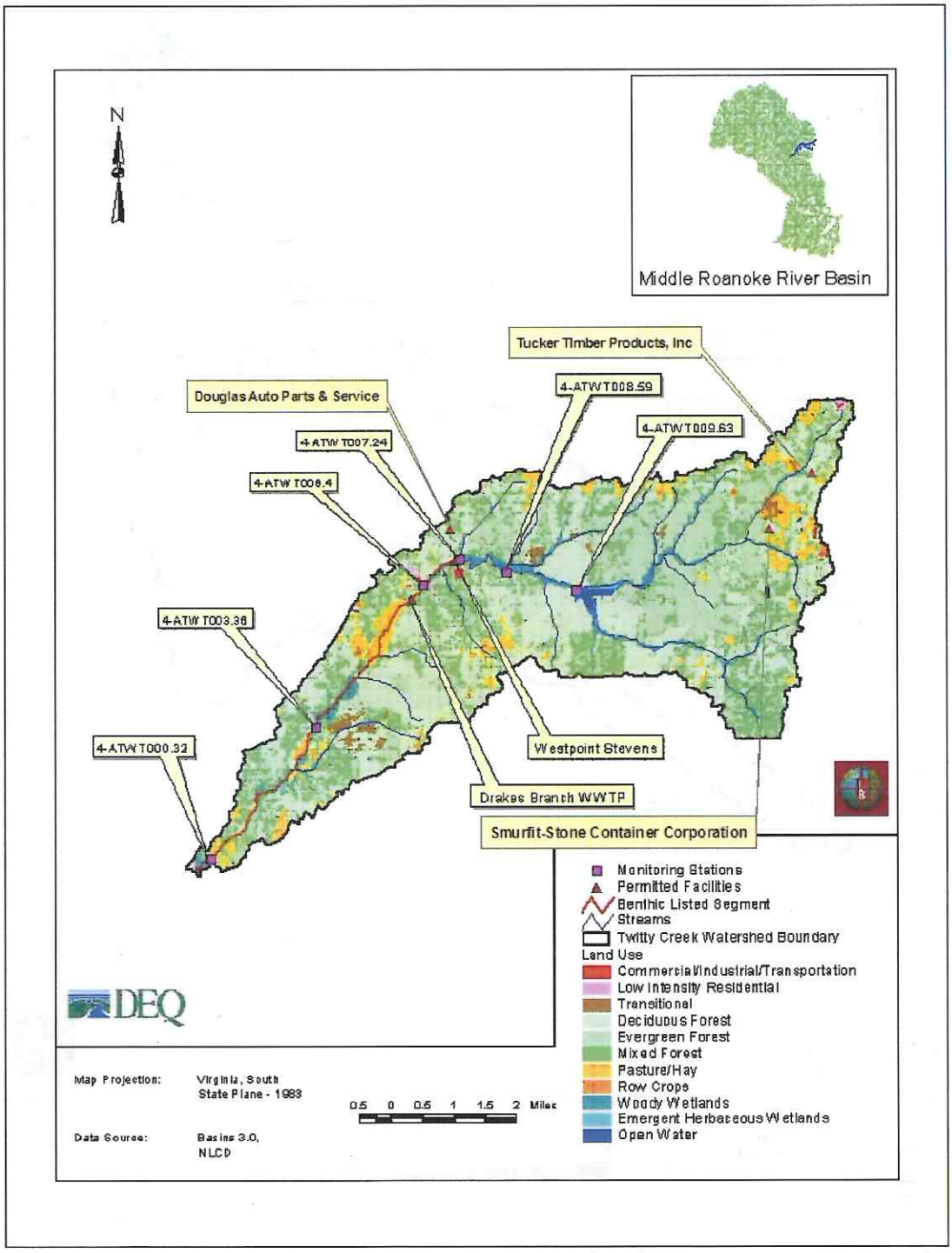


Figure 2-6: Overview of the Twittys Creek Watershed



3.0 Environmental Monitoring

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is impacting the benthic community in the waterbody. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used in the TMDL development for Twittys Creek. Analyzed data sources included available biological and water quality monitoring data measured since 1990, results from recent DEQ monitoring studies to support TMDL development, and the permitted facilities Discharge Monitoring Reports. The collection period, content, and monitored sites for these data sources are summarized in Table 3-1. The locations of permitted discharge facilities and monitoring stations were presented previously in Figures 2-4 and 2-5.

Table 3-1: Inventory of Environmental Monitoring Data for Twittys Creek

Data Type	Collection Period	Description	Monitored Stations								
			ATWT000.32	ATWT003.36	ATWT006.40	ATWT007.24	ATWT008.59	ATWT009.63	ARES001_30	WestPoint Stevens	Drakes Branch WWTP
DEQ Biological Monitoring	1990 – 1997, 2002	Field data sheets and bioassessments forms completed during biomonitoring surveys		X	X	X	X				
DEQ Ambient Water Quality Monitoring	1995, 2003	Water quality parameters measured as part of ambient monitoring program	X					X			
DEQ Field Water Quality Monitoring	1990 – 1997, 2002	Water quality parameters measured during biomonitoring surveys		X	X	X	X				
DEQ Diurnal Study	August 2003	Dissolved oxygen concentrations recorded hourly over a 24 hour period	X	X	X		X				
DEQ Toxicity Study	April 2003	Chronic toxicity testing using instream samples		X	X						
DEQ Special Monitoring Study	November 2003	Metals (dissolved and sediment), nutrients, and TOC at monitoring stations and treatment plant outfalls.		X	X		X		X	X	X
Discharge Monitoring Reports (DMR)	1999 – 2003	Monthly effluent discharge values for permitted facilities								X	X

3.1 Biological Monitoring Data

Twittys Creek was included on the 2002 Virginia 303(d) list based on biomonitoring results obtained for a 5 year assessment period of January 1996 to December 2000. A modified version of the EPA Rapid Bioassessment Protocols II (RBPII) was used to assess the biological condition of the benthic community in the creek. Bioassessments followed a paired reference approach using upstream stations located in the same watershed. The protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures.

The benthic communities at stations ATWT003.36 and ATWT006.40 were assessed as moderately impaired based on comparison with upstream reference stations. Station ATWT006.40 is a recovery station located downstream of the WestPoint Stevens (permit terminated) plant (Figure 2-6). Station ATWT003.36 is a recovery station located further downstream below the Drakes Branch Municipal Wastewater Treatment Plant. The reference stations, ATWT007.24 and ATWT008.59, are located upstream of the treatment plants. Station ATWT007.24 served as the reference station for bioassessments until 2002. In 2002, the reference station was moved upstream to station ATWT008.59 due to the presence of a dam immediately above the old reference station.

3.1.1 Field Data Sheets and Bioassessment Forms

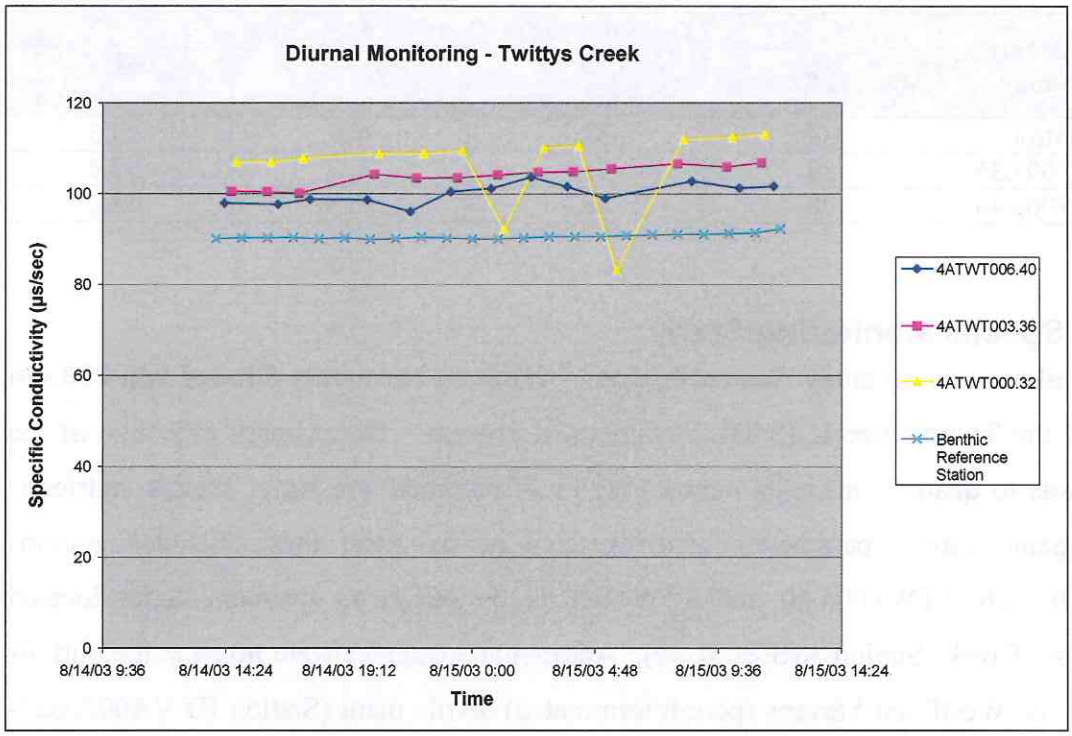
DEQ field data sheets and bioassessment forms used for the biomonitoring stations on Twittys Creek contained the following information:

- Assessment ratings for each station for each survey event
- Field notes from the DEQ biologist conducting the surveys
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of the each survey
- The numbers and types of macroinvertebrates present at each station.

3.1.1.1 Bioassessment Ratings

ATWT003.36 and ATWT006.40 have been typically assessed as moderately impaired since 1990. A summary of assessment ratings for both stations is presented in Table 3-2.

Figure 3-8: Twittys Creek Diurnal Monitoring – Specific Conductivity



3.2.4 Instream Toxicity Testing

Toxicity testing for Twittys Creek was performed on water samples collected by DEQ in April, 2003 for stations ATWT003.36 and ATWT006.40. The EPA Region 3 Laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and Ceriodaphnia dubia as test organisms. Results indicated no statistically significant differences from the control for fathead minnow growth and mortality and Ceriodaphnia dubia mortality and reproduction. Results are summarized in Table 3-8 and Table 3-9.

Table 3-8: Chronic Toxicity Testing Results for Fathead Minnows

Monitoring Station	Test Organism- Fathead Minnow					
	Mean % Survival	Std. Dev. Survival	Coeff. Var. Survival	Mean Weight	Std. Dev. Weight	Coeff. Var. Weight
Control	100	0	0	0.67	0.07	10.6
ATWT003.36	42.5	40.31	94.9	0.73	0.11	14.8
ATWT006.40	62.5	29.86	47.8	0.67	0.08	11.9

Table 3-9: Chronic Toxicity Testing Results for Ceriodaphnia dubia

Monitoring Station	Test Organism- Ceriodaphnia dubia			
	Mean % Survival	Average Reproduction	Std. Dev. Reproduction	Coeff. Var. Reproduction
Control	100	32.1	8.2	25.5
ATWT003.36	89	34.4	13.7	39.9
ATWT006.40	78	28.7	15.3	53.2

3.2.5 Special Monitoring Study

A special monitoring study was conducted by DEQ on November 5th and 6th, 2003 to support the Twittys Creek TMDL development process. The primary objective of the study was to quantify instream concentrations of potential stressors. Metals, nutrients, and organic carbon parameters were sampled at six sites; these included stations ATWT003.36, ATWT006.40, and ATWT008.59, as well as an upstream station located on Reeses Creek (Station ARES001.30). Additionally samples were taken at the outfalls of both the WestPoint Stevens (permit terminated) textile plant (Station ID VA0050822-001) and the Drakes Branch WWTP (Station ID VA0084433-001). Results of the study are presented in Table 3-10. Stations are presented in order of upstream to downstream, from the left column to the right column. Data indicated the following:

- Some metals parameters were elevated at the outfalls of the former WestPoint Stevens (permit terminated) and the Drakes Branch WWTP. However, instream monitoring indicated Twittys Creek was minimally impacted by plant effluent, most likely due to effluent dilution upon entering the creek. In most cases, instream values for metals were comparable at upstream and downstream locations. Sediment copper concentrations were slightly elevated at the biomonitoring station downstream of the former WestPoint Stevens (permit terminated) plant (17 mg/kg at station ATWT006.40) as compared to the reference station (11.4 mg/kg at station ATWT008.59). Dissolved copper concentrations were low at both of these locations (0.78 ug/L and 1.01 ug/L, respectively). In some cases, metals concentrations were slightly higher at upstream locations, such as for nickel.
- None of the instream dissolved concentrations of metals tested exceeded acute or chronic water quality standards for aquatic life. Water quality standards for

metals are dependent on hardness as well as an applicable water effect ratio (WER). For this analysis, metals standards were computed based on an observed hardness value of 44.5 mg/L as CaCO3 for the sampling day. A conservative WER of 1 was assumed.

- Total organic carbon concentrations were fairly consistent across all monitored locations and ranged from 4.4 to 6.7 mg/L.
- Total phosphorus, total Kjeldahl nitrogen, nitrate and nitrite concentrations were elevated at the outfalls of both treatment plants. However, instream concentrations of these nutrient parameters indicate that the creek is not impacted by the plant effluents. Nutrient concentrations were consistently low at both upstream and downstream locations.

Table 3-10: Results of Special Monitoring Study for Twittys Creek

Parameter	Site Number					
	ARES 001.30	ATWT 008.59	Stevens Outfall VA0050822-001	ATWT 006.40	Drakes Branch Outfall VA0084433-001	ATWT 003.36
Aluminum, Dissolved (µg/L)	2.43	13.07	14.50	9.35	7.81	6.58
Aluminum, Sediment (mg/kg)	4070	4890	12500	8850	N/A	6990
Antimony, Dissolved (µg/L)	0.10	0.10	2.24	0.10	0.22	0.10
Antimony, Sediment (mg/kg)	5	5	5	5	N/A	5
Arsenic, Dissolved (µg/L)	0.22	0.31	5.08	0.27	0.10	0.29
Arsenic, Sediment (mg/kg)	5	5	5	5	N/A	5
Barium, Dissolved (µg/L)	13	10	13	15	10	15
Beryllium, Dissolved (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1
Beryllium, Sediment (mg/kg)	5	5	5	5	N/A	5
Cadmium, Dissolved (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1
Cadmium, Sediment (mg/kg)	1	1	1	1	N/A	1
Calcium, Dissolved (mg/L)	9.7	6.4	24.0	9.8	17.0	9.8
Chromium, Dissolved (µg/L)	0.10	0.21	1.32	0.10	0.10	0.10
Chromium, Sediment (mg/kg)	17.7	22.9	58.9	23.7	N/A	18.6
Copper, Dissolved (µg/L)	0.44	0.78	17.00	1.01	25.00	0.97
Copper, Sediment (mg/kg)	6.5	11.4	42.3	17.0	N/A	12.3
Hardness, (mg/L as CACO3)	46	30	93	45	67	44
Iron, Dissolved (µg/L)	111	399	516	374	50	342
Iron, Sediment (mg/kg)	8730	12300	21200	18400	N/A	12700
Lead, Dissolved (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1
Lead, Sediment (mg/kg)	5	5	11	10	N/A	8

Table 3-10: Results of Special Monitoring Study for Twittys Creek (Continued)

Parameter	Site Number					
	ARES 001.30	ATWT 008.59	Stevens Outfall VA0050822-001	ATWT 006.40	Drakes Branch Outfall VA0084433-001	ATWT 003.36
Magnesium, Dissolved (mg/L)	5.4	3.4	8.0	4.9	5.9	4.7
Manganese, Dissolved (µg/L)	53	64	317	111	0.8	128
Manganese, Sediment (mg/kg)	129	183	655	361	N/A	455
Mercury, Sediment (mg/kg)	0.1	0.1	0.1	0.1	N/A	0.1
Mercury, Filtered (NG/L)	1.50	1.75	2.56	1.58	2.75	1.50
Nickel, Dissolved (µg/L)	0.36	0.44	7.02	0.42	3.69	0.4
Nickel, Sediment (mg/kg)	7.8	13.9	17.3	11.0	N/A	9.1
Nitrate, Total (mg/L)	0.04	0.07	19.12	0.22	16.57	0.45
Nitrite, Total (mg/L)	0.01	0.01	0.08	0.01	0.01	0.01
Nitrogen, Total Kjeldahl (mg/L)	0.4	0.3	1.5	0.4	1.1	0.3
Phosphorus, Total (mg/L)	0.1	0.1	2.3	0.1	1.8	0.1
Selenium, Dissolved (µg/L)	0.5	0.5	1.4	0.5	0.5	0.5
Selenium, Sediment (mg/kg)	1	1	1	1	N/A	1
Silver, Dissolved (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1
Silver, Sediment (mg/kg)	1	1	1	1	N/A	1
Thallium, Dissolved (µg/L)	0.2	0.2	0.2	0.2	0.2	0.2
Thallium, Sediment (mg/kg)	5	5	5	5	N/A	5
Total Organic Carbon (mg/L)	5.3	6.7	6.7	6.3	4.4	5.2
Zinc, Dissolved (µg/L)	1	1	109	1	30	1
Zinc, Sediment (mg/kg)	18.6	24.8	200.0	28.5	N/A	27.5

3.3 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for the former WestPoint Stevens (permit terminated) and Town of Drakes Branch treatment plants were obtained from DEQ and compared with permitted discharge limits. The level of compliance for permitted discharge parameters is discussed below. Table 3-11 and Table 3-12 summarize water quality violations at the Drakes Branch WWTP (permit terminated) and , respectively.

- Average monthly values for monitored parameters at Drakes Branch WWTP are shown in Figures 3-9 through 3-15. These data indicate that most monitored parameters have been in general compliance over the past several years. There has been one violation of the maximum ammonia concentration, and one violation of the maximum total suspended solids concentration. Also, copper concentrations have exceeded the permit limit on 3 of 5 occasions.

- Average monthly values for monitored parameters at the former WestPoint Stevens (permit terminated) are shown in Figures 3-16 through 3-22. These DMR also indicate that most monitored parameters have been in general compliance over the past several years. There have been two violations of the maximum BOD5 concentration, and no violations for all other monitored parameters.

- Whole Effluent Toxicity (WET) results for the former WestPoint Stevens (permit terminated) effluent indicated that 6 out of 19 samples between 1999 and 2003 have failed acute toxicity tests for Ceriodaphnia dubia.

Table 3-11: Summary of Drakes Branch WWTP Effluent Water Quality Conditions

Water Quality Parameter	Period of record	No. of Violations	Dates
NH3	2001 to 2003	1	Jan 03
BOD5	1999 to 2003	0	
Cl2, Total Contact	1999 to 2003	0	
Copper	2001 to 2003	3	Dec 01, Feb 02, Jan 03
DO	1999 to 2003	0	
pH	1999 to 2003	0	
TSS	1999 to 2003	1	Dec 01

Table 3-12: Summary of WestPoint Stevens (permit terminated) Effluent Water Quality Conditions

Water Quality Parameter	Period of record	No. of Violations	Dates
NH3	2001 to 2003	0	
BOD5	1999 to 2003	2	July, Sept 99
Cl2, Total Contact	1999 to 2003	0	
COD	2001 to 2003	0	
DO	1999 to 2003	0	
pH	1999 to 2003	0	
TSS	1999 to 2003	0	

Figure 3-9: Drakes Branch WWTP - Ammonia

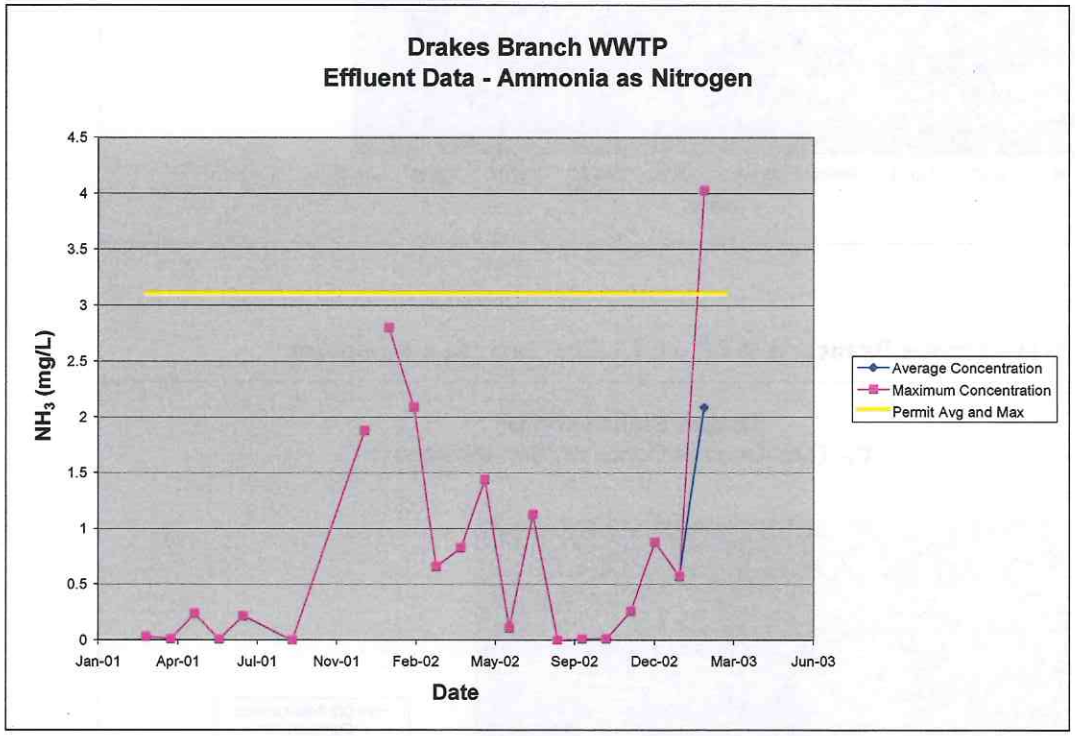


Figure 3-10: Drakes Branch WWTP – BOD5

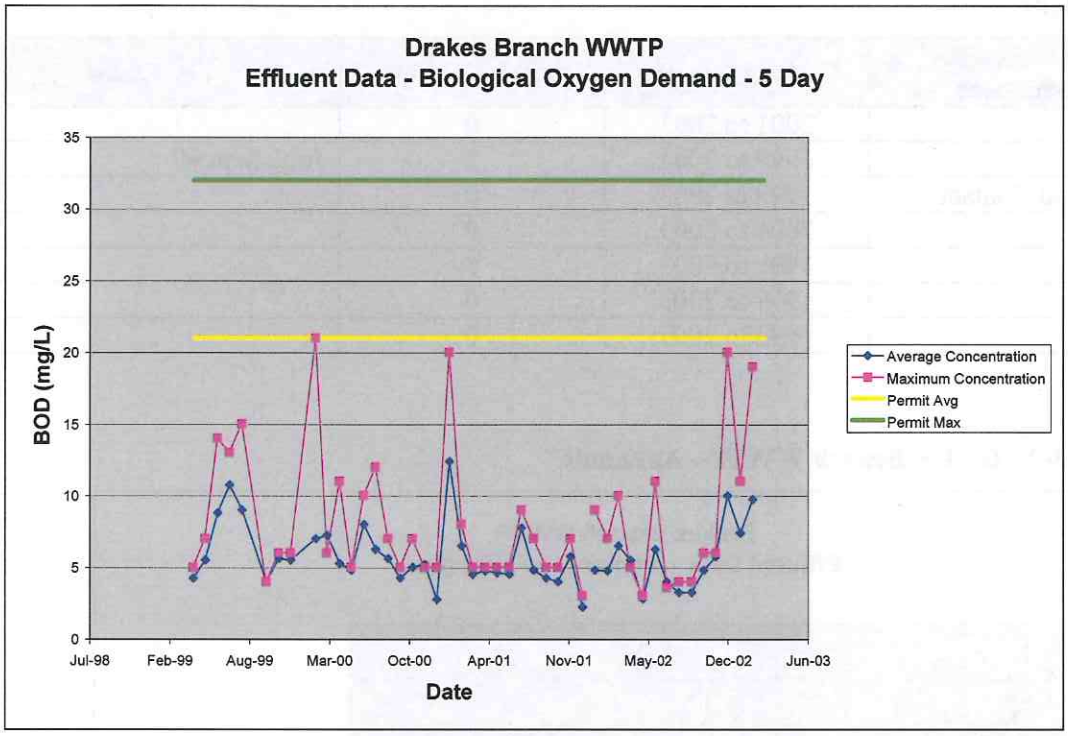


Figure 3-11: Drakes Branch WWTP – CL2 Concentration Minimum

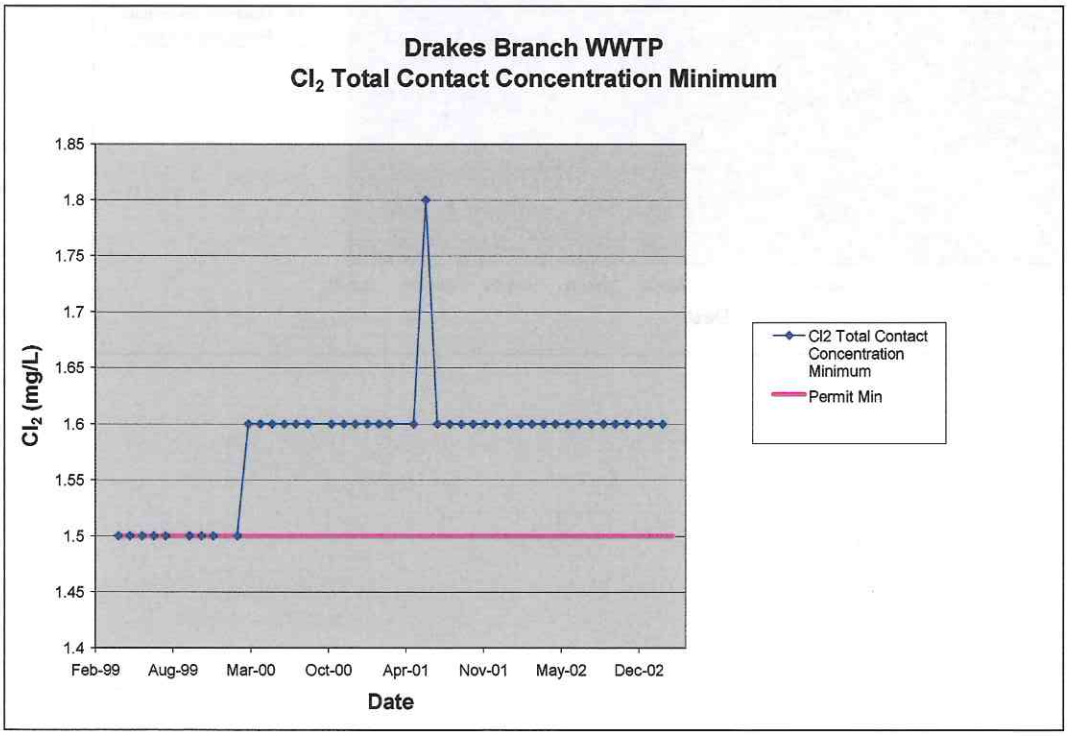


Figure 3-16: WestPoint Stevens – Ammonia (Permit Terminated)

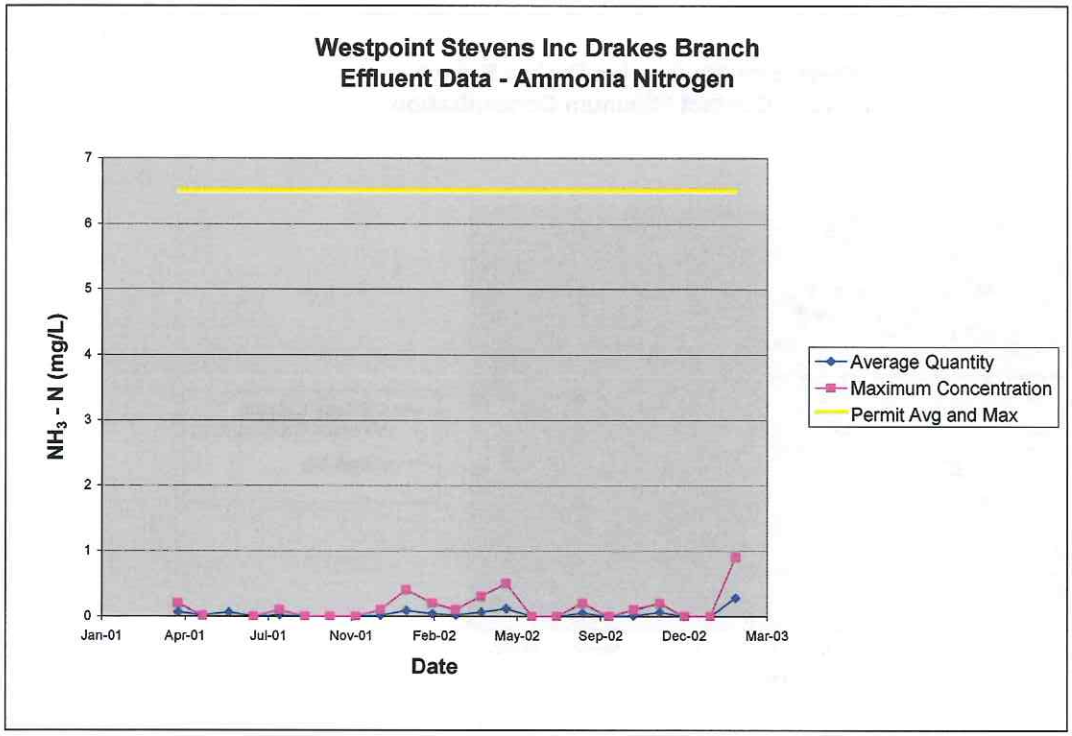


Figure 3-17: WestPoint Stevens – BOD5 (Permit Terminated)

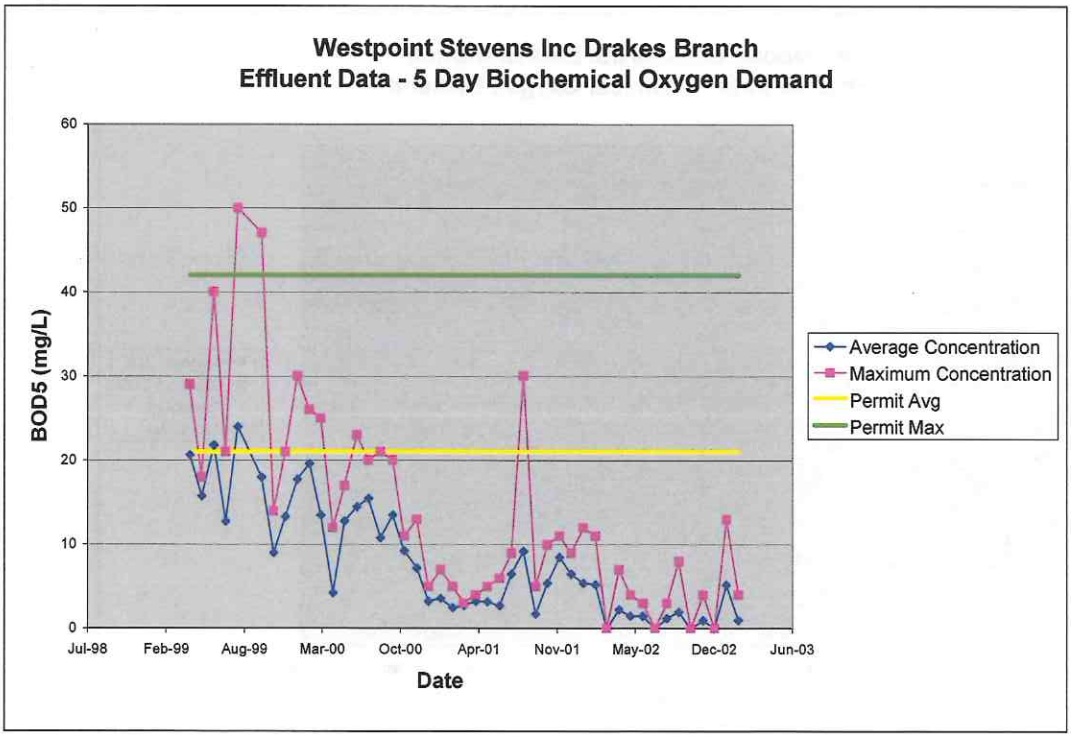


Figure 3-18: WestPoint Stevens – CL2 Minimum Concentration (Permit Terminated)

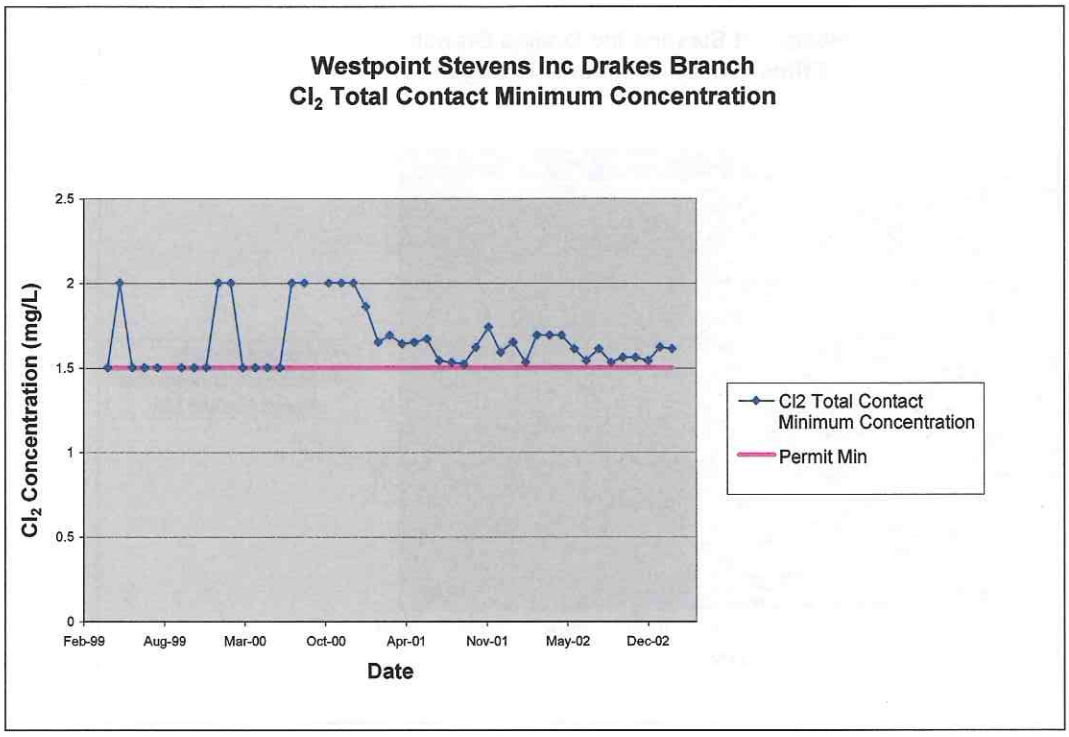


Figure 3-19: WestPoint Stevens – Chemical Oxygen Demand (Permit Terminated)

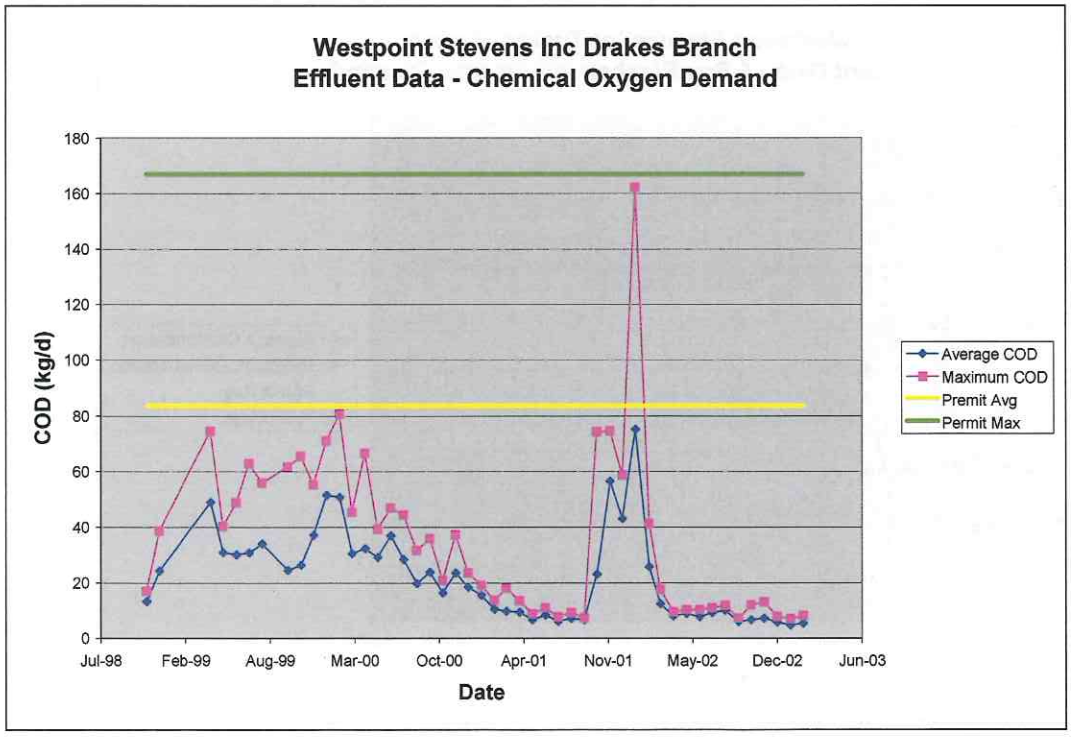


Figure 3-20: WestPoint Stevens – Dissolved Oxygen (Permit Terminated)

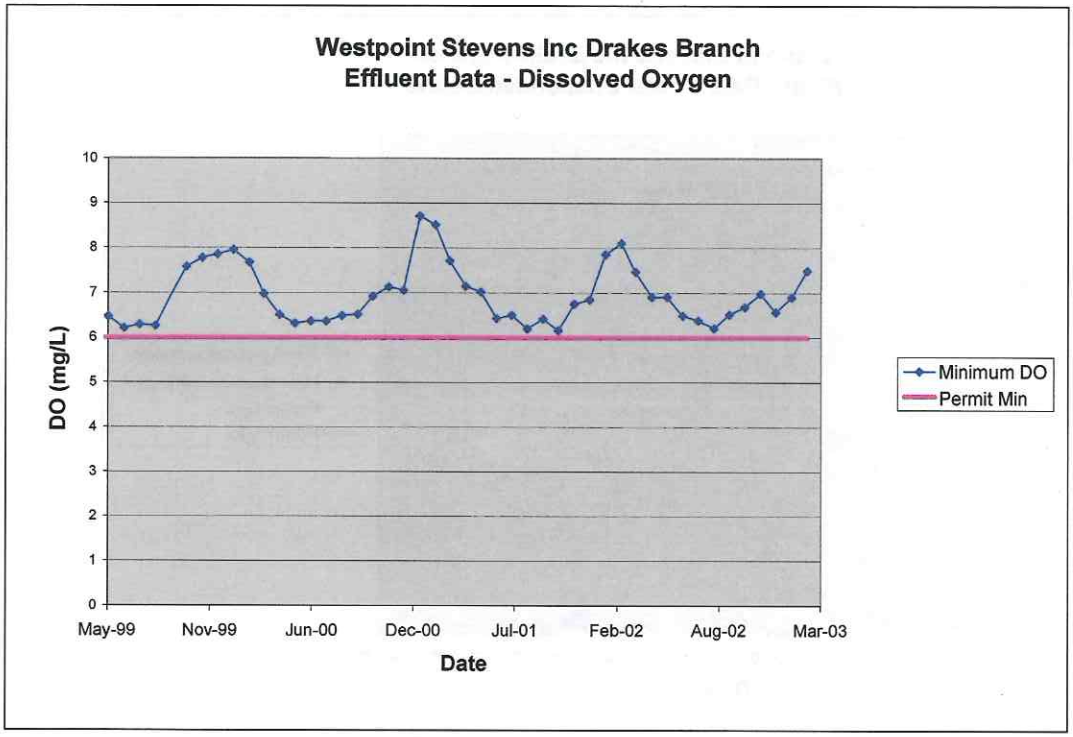


Figure 3-21: WestPoint Stevens – pH (Permit Terminated)

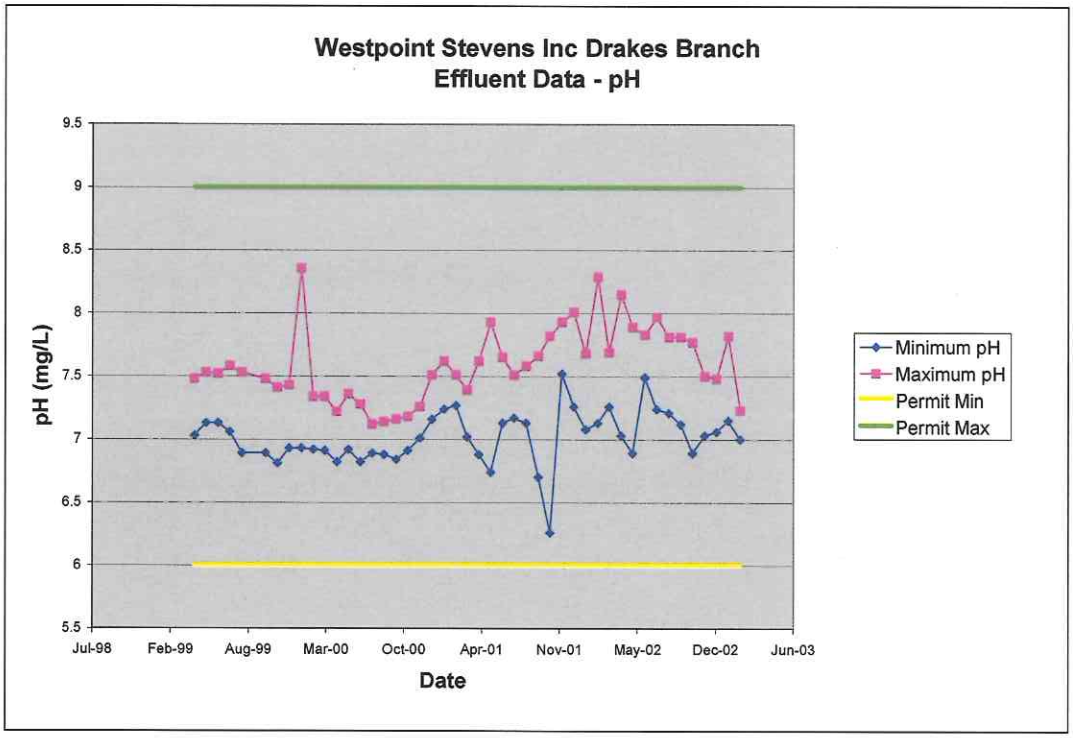
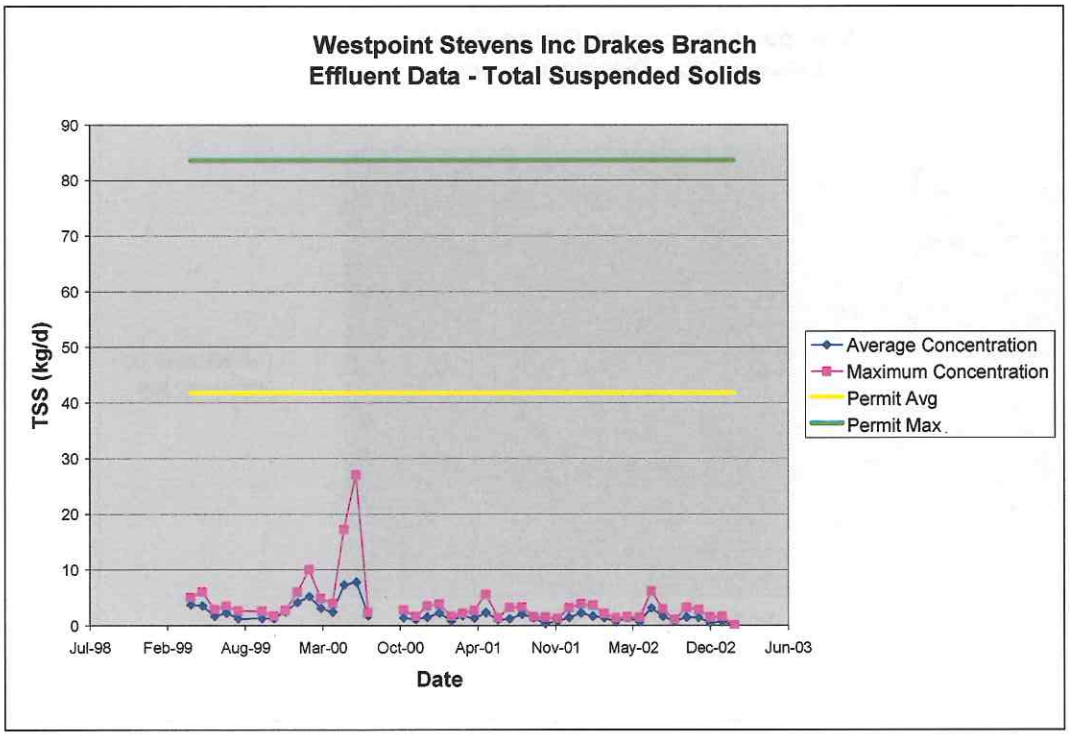


Figure 3-22: WestPoint Stevens – Total Suspended Solids (Permit Terminated)



4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) that are impacting the benthic macroinvertebrate community. Stressor identification for Twittys Creek was performed using the available environmental monitoring and watershed characterization data discussed in previous sections.

The primary stressor to Twittys Creek was determined based on evaluations of candidate stressors that can potentially impact the creek. The 2002 303(d) Impaired Waters Fact Sheet indicated "siltation from municipal and industrial point sources" as a possible source of the impairment to the creek. Therefore, sediment was considered and evaluated as a candidate stressor along with other typical stressors including organic matter, nutrients, pH, temperature, and toxics. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed.

4.1 Organics

Excessive inputs of organic matter can lead to oxygen depletion, which adversely affects the survival and growth of benthic macroinvertebrates. Common sources of organic matter loading include wastewater discharges and agricultural runoff.

DMR data indicate that both permitted facilities in the watershed have been in compliance for BOD5 since 2001 (Figures 3-10 and 3-17). Prior to treatment plant upgrades in 2001, the WestPoint Stevens (permit terminated) treatment facility reported two violations of average and maximum BOD5 effluent concentration in the summer of 1999 as shown in Table 3-12.

Diurnal monitoring and biomonitoring field data indicated adequate levels of dissolved oxygen in Twittys Creek. No violations of water quality criteria for dissolved oxygen were observed as shown in Figures 3-2 and 3-5. Therefore, the instream dissolved oxygen concentration appears to be adequate to support a healthy benthic community in the creek. For these reasons, excessive organic matter loading does not appear to be impairing the benthic community of Twittys Creek.

4.2 Nutrients

Excessive nutrient inputs (nitrogen and phosphorus) can lead to eutrophication (algal blooms) and low dissolved oxygen concentrations, which may adversely affect the survival of benthic macroinvertebrates. Specifically, dissolved oxygen levels in eutrophic water bodies can become low during the overnight hours, when plants cease to photosynthesize, but continue to respire.

As indicated previously, no violations of water quality criteria for dissolved oxygen were observed during diurnal and biomonitoring field studies. Diurnal monitoring indicated that overnight dissolved oxygen concentrations never dropped below 6 mg/L at any station on Twittys Creek. Results from the special monitoring study performed by DEQ in November 2003 indicated that nutrient concentrations were consistently low at both upstream and downstream monitoring locations (Table 3-10). Based on this evidence, low dissolved oxygen concentrations resulting from excessive nutrient loading and algal growth does not appear to be the cause of the benthic impairment in Twittys Creek.

4.3 Temperature and pH

Benthic macroinvertebrates require specific temperature and pH ranges in order to survive. Shifts in these parameters, potentially due to factors such as wastewater discharge or urban runoff, may adversely affect the health and composition of the benthic community.

Diurnal monitoring and biomonitoring field data indicated adequate levels of dissolved temperature and pH in Twittys Creek. No violations of water quality criteria for temperature or pH were observed as shown in Figures 3-1, 3-4, 3-6, and 3-7. In addition, both treatment plant effluents have been in compliance for pH as shown in Figures 3-14 and 3-21. Based on this evidence, neither temperature nor pH levels appear to be impairing the benthic community in Twittys Creek.

4.4 Sedimentation

Excessive sedimentation can adversely affect invertebrate communities through the loss of habitat or food sources. Sediment loading can result in siltation of benthic habitat, and subsequent changes in invertebrate composition. Sedimentation may also alter or limit

invertebrate food sources. Potential origins of non-point source sediment include agricultural runoff, urban runoff, forestry operations, construction sites, mining operations, and treatment plants.

The 303(d) fact sheet lists the primary source of impairment in Twittys Creek as "siltation from municipal and industrial point sources." DMR data, however, indicated that both plants have been in compliance for total suspended solids (Figures 3-15 and 3-22), with the exception of one violation for the Drakes Branch WWTP in December, 2001. Therefore, it does not appear that the permitted facilities are responsible for sediment problems in the creek.

Review of the DEQ biologist's field notes indicated that sedimentation problems are not related to point sources, but rather to non-point source runoff and the presence of beaver dams further downstream. In particular, field notes indicated non-point source runoff from the Town of Drakes Branch was impacting station the benthic community at station ATWT006.40. Instream habitat at the station was characterized as "very limited" and comprised almost entirely of sand substrate. Visual inspections of the station performed in April and November of 2003 also revealed some degraded stream banks at the confluence of Twittys Creek and the unnamed tributary draining the Town of Drakes Branch. Further downstream, beaver dams present near station ATWT003.36 may trap excess sediment, reducing benthic macroinvertebrate habitat.

Habitat assessments performed in 2002 indicated lower sedimentation scores at both impaired locations compared to the reference station (Table 3-3). In addition, scores for substrate embeddedness were lower at both impaired stations compared to the reference station. The lower scores at the recovery stations relative to the reference generally indicate that the habitat conditions are worse at the downstream location which can cause an impact to the benthic macroinvertebrate community in the stream.

Based on this evidence, it appears that sediment is a stressor impacting the benthic invertebrate community in Twittys Creek.

4.5 Toxics

Recent effluent monitoring data indicated that both the WestPoint Stevens (permit terminated) and Town of Drakes Branch wastewater treatment facilities have been discharging elevated levels of copper. The Town of Drakes Branch WWTP has violated permitted copper limits in three out of five samples since 2002 (Figure 3-12). WestPoint Stevens (permit terminated) treatment plant effluent was found to have elevated levels of copper, nickel, and zinc in a monitoring study performed in 2002 (Albion Environmental). In addition, the WestPoint Stevens (permit terminated) plant has failed 6 out of 19 whole effluent toxicity tests in the last four years. The cause of toxicity has not been determined, but officials from WestPoint Stevens (permit terminated) suspect high metals concentrations.

Based on discussions with the Town of Drakes Branch water and wastewater treatment plants operators, it was determined that the potable water for the town is high in copper due to leachate from copper piping. Consequently, the Drakes Branch water treatment facility has started adding soda ash to their source water prior to distribution to control the copper leaching problem (Sands 2003, Personal Communication). The WestPoint Stevens (permit terminated) treatment plant is under a compliance schedule to meet permitted effluent limits for copper, nickel, and zinc and has implemented an intensive water sampling program in their facility. The sampling indicated that although the process source water was low in metals, the potable tap water at the onsite laboratory was high in copper (WestPoint Stevens Quarterly Report to DEQ, 2003). This is a further indication that copper is being leached from the pipes at the facility.

As a result of these findings, additional sampling was performed on Twittys Creek by DEQ in November 2003 to assess instream levels of potential stressors, including copper and other metals. In addition, samples were tested for total organic carbon (TOC) as a surrogate indicator of the presence of polyvinyl alcohol (PVA). PVA is used by WestPoint Stevens for textile sizing.

Results of the special monitoring study indicated that metals concentrations tended to be elevated in both treatment plant outfalls. The instream impact, however, appears to be

minimal as evidenced by fairly comparable concentrations for most monitored parameters at upstream and downstream biomonitoring locations. Furthermore, none of the instream dissolved metals concentrations violated acute or chronic water quality standards. Dissolved copper concentrations were about 1 µg/L at all instream stations compared to acute and chronic standards of 8.4 and 6.0 µg/L, computed based on an observed hardness concentration of 44.5 mg/L as $CaCO_3$ at the impaired stations. Sediment copper concentrations were slightly elevated at the station downstream of the WestPoint Stevens (permit terminated) plant, but the Twittys Creek does not appear to be heavily contaminated with metals. Results for TOC were consistent across all monitored locations, implying that PVA is not a likely stressor to the benthic community.

Instream toxicity testing results from samples collected in April 2003 support the conclusion that toxins are not significantly impacting Twittys Creek. Test results for the two impaired stations, ATWT003.36 and ATWT006.40, indicated that samples were not toxic to test organisms. However, survival rates of test organisms were less than 100%, implying some potential degree of toxicity in samples. In particular, fathead minnows exhibited mean survival rates of 42.5% and 62.5% for the two impaired stations, as shown in Table 3-8. Due to the high coefficient of variation of replicate test samples, the toxicity of these samples is not considered to be *statistically* significant.

Therefore, based on these findings, toxicity does not appear to be a significant stressor to the benthic community in Twittys Creek. Any toxic impacts from treatment plant effluents appear to be minimal.

4.6 Stressor Identification Summary

Sediment was identified as the primary stressor to the benthic community in Twittys Creek based on candidate stressor evaluations. Sedimentation problems appear to originate mainly from non-point sources in the watershed, including runoff from the Town of Drakes Branch. This runoff has contributed to erosion problems, loss of instream habitat, and substrate conditions that are not conducive to a healthy benthic invertebrate assemblage. The predominance of sand and other sediment particles in the

substrate is detrimental to many invertebrate taxa, and is likely responsible for the poor condition of the benthic assemblage.

Improvement of the benthic invertebrate community in Twittys Creek is dependent upon reducing non-point source sediment loading to the creek as well as managing stormwater runoff that leads to streambank erosion and sedimentation problems. These measures should serve to improve benthic habitat and subsequently restore invertebrate populations in the creek. Therefore, a sediment TMDL was developed for Twittys Creek.

Although toxicity does not appear to be a significant stressor in Twittys Creek, some evidence does suggest that treatment plant effluents *may potentially* have some toxicity impact on the benthic community in the creek. These impacts appear to be minimal based on the available data. Compliance with permitted limits would serve to alleviate any minor impact these effluents may have on the benthic community. Currently, WestPoint Stevens (permit terminated) is under a compliance schedule to meet permitted effluent limits for total recoverable copper, zinc, and nickel by April, 2007. In addition, the Town of Drakes Branch WWTP is under a compliance schedule to meet their permitted effluent limit for total copper.

6.0 Sediment Load Determination

A reference watershed approach was used to develop the sediment TMDL for the Twittys Creek watershed as discussed in the previous section. The drainage area above the non-impaired reference biomonitoring station located at river mile 8.59 served as the reference watershed (Figure 5-1). The sediment loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Twittys Creek.

6.1 Sediment Source Assessment

Excessive sedimentation can adversely affect benthic invertebrate communities through the loss of habitat or food sources. Sediment can be delivered to the stream from point sources located in the watershed and it can be carried in the form of non-point source runoff from non-vegetated or protected land areas. In addition, sediment can be generated in the stream through the processes of scour and deposition which are primarily a function of stream flow. During periods of high flow, erosion of the stream channel occurs. The eroded materials are deposited downstream as stream flow decreases. These processes adversely impact the benthic macroinvertebrate community through loss of habitat and degradation of water quality.

Potential sediment sources within the Twittys Creek watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Non-Point Sources

The erosion of land is dependent upon many factors including land use type and cover, soils type, and topography. The land use types in the Twittys Creek watershed were characterized using NLCD data, while soil types were characterized using the STATSGO database. The land use distribution for the Twittys Creek watershed was previously shown in Table 2-3 and a summary of soil types was provided in Table 2-1. The delivery

of eroded soils to the stream is primarily influenced by watershed size. Sediment loadings from generalized land use types present in the Twittys Creek watershed are discussed below.

Forested Lands

Sediment loads from forested lands are typically low due to extensive root systems and vegetative cover that serve to stabilize soils. In addition, forest canopies intercept and dampen rainfall impacts.

Agricultural lands

Sediment loads from agricultural lands tend to be elevated due to the exposure of soil that occurs in agricultural practices. Cropland and pastureland are two sources of elevated sediment loads.

Developed Lands

Developed lands consist of both pervious and impervious surfaces. Impervious surfaces are not subject to soil erosion, but sediment loads may result from the washoff of solids deposited on impervious surfaces. Sediment loads from developed lands tend to be high. In addition, elevated levels of uncontrolled stormwater runoff from developed lands contribute to streambank erosion as discussed below.

Water/Wetlands

The amount of sediment loading from water and wetland areas typically is not significant.

Barren Lands

Transitional lands represent areas of sparse vegetative cover often due to land use activities such as forest clearcuts and construction lands. Due to increased levels of soil exposure, sediment loads from transitional lands typically are high.

6.1.2 Point Sources

Sediment loadings from point sources are attributable to the suspended solids present in discharge effluent. The Town of Drakes Branch wastewater treatment facility, Douglas

Auto Parts and Service, Tucker Timber Products, Inc, and Smurfit-Stone Container Corporation, and construction permits all discharge solids to Twittys Creek.

6.1.3 Instream Bank Erosion

Sediment derived from instream bank erosion is also dependent upon numerous watershed characteristics. Land use types present in the watershed may affect hydrology of the watershed. In particular, highly developed lands may lead to increased stream flows that erode the stream channel and banks. Likewise, watersheds defined by steep topography may experience high levels of runoff that cause instream erosion. The level of instream erosion is dependent on the erodibility of the soil, normally defined as the soil K factor. Since the Twittys Creek watershed is primarily forested, the overall amount of sediment generated by instream erosion would be expected to be low.

6.2 Technical Approach for Estimating Sediment Loads

6.2.1 Non-Point Source Sediment

For the purpose of TMDL development, annual sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model.

GWLF is a time variable simulation model that simulates hydrology and sediment loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is

modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Erosion and sediment loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a sediment delivery ratio is applied to determine the sediment loadings to the stream. Sediment loadings from each source area are summed to obtain a watershed total.

6.2.2 Point Source Loadings

Five point source facilities are present in the Twittys Creek impaired watershed as shown in Table 6-1. No point sources are present in the reference watershed. For the purpose of TMDL development, annual point source loadings were computed based on the permitted discharge loading rate for total suspended solids for each facility.

Table 6-1: Point Sources in Twittys Creek Watershed

Facility Name	Permit No.	Permitted Total Suspended Solids (kg/day)	Annual Sediment Loading (tons/year)
Drakes Branch STP	VA0084433	9.1	18.3
Douglas Auto Parts and Service	VAR051752	Stormwater	3.6
Tucker Timber Products, Inc	VAR051513	Stormwater	16.2
Smurfit-Stone Container Corp	VAR050592	Stormwater	10.5
Construction	Varies	Construction	8.9

6.2.3 Instream Erosion

Instream erosion for Twittys Creek was calculated using a spatial technique developed by Evans et al. (2003) that estimates streambank erosion based on watershed characteristics. Using this method, a watershed-specific lateral erosion rate is calculated as follows:

$$LER = aQ^{0.6}$$

Where:
LER = an estimated lateral erosion rate, expressed as meters per month

6.5 Existing Sediment Loadings – All Sources

In summary, average annual sediment loads for the Twittys Creek impaired and reference watersheds were determined as follows:

- Erosion and sediment yield from land sources were modeled using GWLF.
- Instream bank erosion was computed based on the method described by Evans et al. (2003).
- Sediment loads from point sources were calculated based on the permitted total suspended solids loading rate for each facility.

In addition, average annual sediment loads for an area-adjusted reference watershed were computed for the purpose of TMDL development. As stated previously, under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Twittys Creek reference watershed is smaller than the impaired watershed, sediment loadings for the reference watershed needed to be adjusted to reflect the size of the impaired watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed. In addition, instream erosion for the adjusted reference watershed was calculated using the total stream length of the impaired watershed.

Average annual sediment loads from all sources for the Twittys Creek impaired, reference, and area-adjusted reference watersheds are summarized in Table 6-7. The total existing sediment load in the impaired watershed is 1,087 tons per year. The area-adjusted reference watershed load of 890 tons per year represents the TMDL endpoint. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Twittys Creek.

Table 6-7: Twittys Creek Average Annual Sediment Loadings (tons/yr)

Source	Land Use Type	Reference Watershed	Area-Adjusted Reference Watershed	Impaired Watershed
Land Sources	Deciduous Forest	37.7	56.5	61.0
	Evergreen Forest	27.3	41.0	31.5
	Mixed Forest	15.9	23.8	25.9
	Pasture/Hay	192.3	288.5	354.6
	Row Crop	75.1	112.7	142.0
	Low Intensity Residential	0.3	0.5	0.7
	Commercial/Industrial	6.5	11.2	15.7
	Transitional	186.5	279.8	355.0
	Open Water	0.0	0.0	0.0
	Woody Wetlands	0.0	0.0	0.0
	Emergent Herbaceous	0.0	0.0	0.0
Instream Erosion	-	48.5	76.1	80.5
Point Sources	-	0.0	0.0	20.4
Total		590.0	890.1	1087.3

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Sediment was identified as the primary stressor to the benthic community in Twittys Creek and a reference watershed approach was used for TMDL development. The total average annual sediment loading for the area-adjusted reference watershed (Table 6-7) represents the TMDL endpoint for the Twittys Creek impaired watershed. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Twittys Creek.

7.1 Basis for TMDL Allocations

Sediment TMDL allocations for Twittys creek were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Sediment Load of the Area-Adjusted Reference Watershed

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for Twittys Creek to account for uncertainties in the methodologies used to determine sediment loadings.

7.1.2 Wasteload Allocation

The wasteload allocated to point sources in the watershed was based on the permitted discharge loading rate for total suspended solids for each facility as shown in Table 7-1.

Because the facilities typically contribute only non-settleable solids, and their overall contribution (6.7%) to the total annual watershed sediment load is small, no reductions are required for these sources.

Table 7-1: Recommended Wasteload Allocations for Twittys Creek

Facility Name	Permit Number	Permitted Load (tons/yr)	Allocated Load (tons/yr)	Percent Reduction
Drakes Branch STP	VA0084433	18.3	18.3	0
Douglas Auto Parts and Service	VAR051752	3.6	3.6	0
Tucker Timber Products, Inc	VAR051513	16.2	16.2	0
Smurfit-Stone Container Corp	VAR050592	10.5	10.5	0
Future Growth left over from WestPoint Stevens		2.1	2.1*	
Construction		8.9	8.9	0
Total	-	59.6	59.6	0

Note: Westpoint Stevens WLA was 16.8 tons/yr. Drakes Branch STP expanded from 80,000 gpd to 400,000 gpd. Drakes Branch WLA was increased using the WestPoint Stevens WLA and the additional amount was applied to future growth. The stormwater WLA's and the construction is a transfer from the LA.

7.1.3 Load Allocation

Load allocations for non-point sources were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 28%, the sediment TMDL endpoint is achieved. The existing and allocated sediment loads for each non-point source in the Twittys Creek watershed are presented in Table 7-2. In addition, the necessary percent reduction is shown for each source.

Table 7-2: Recommended Load Allocations for Twittys Creek

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	61.0	61.0	0
	Evergreen Forest	31.5	31.5	0
	Mixed Forest	25.9	25.9	0
	Pasture/Hay	354.6	247.6	30
	Row Crop	142.0	99.2	30
	Low Intensity Residential	0.7	0.5	30
	Commercial/Industrial	15.7	11.0	30
	Open Water	0.0	0.0	0
	Woody Wetlands	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
	Transitional	315.8	208.7	41
Instream Erosion	-	80.5	56.2	30
Total		1027.7	741.5	28

7.2 Overall Recommended TMDL Allocations

The total load and wasteload allocations and margin of safety for Twittys Creek are summarized in Table 7-3. Recommended allocations for each source in the watershed are provided in Table 7-4. Overall, the sediment load in the Twittys Creek watershed must be reduced by 26% to meet the established TMDL endpoint.

Table 7-3: Sediment TMDL for Twittys Creek (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
890.1	741.5	59.6	89.0

Note: Existing Stormwater and construction loads were taken out of the Load allocation and added to the WLA.

Table 7-4: Recommended TMDL Allocations for Twittys Creek

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	61.0	61.0	0
	Evergreen Forest	31.5	31.5	0
	Mixed Forest	25.9	25.9	0
	Pasture/Hay	354.6	247.6	30
	Row Crop	142.0	99.2	30
	Low Intensity Residential	0.7	0.5	30
	Commercial/Industrial	15.7	11.0	30
	Open Water	0.0	0.0	0
	Woody Wetlands	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
	Transitional	315.8	208.7	34
Instream Erosion	-	80.5	56.2	30
Point Sources	-	59.6	59.6	0
Total		1087.3	801.1	26

7.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of Twittys Creek, the primary stressor to the benthic impairment in the creek is excessive sediment loading, which has led to siltation and the loss of benthic habitat. Sediment is primarily delivered to the stream in stormwater runoff from non-point sources. On an average annual basis, non-point sources and in-stream erosion account for 98.1% of the total sediment load to the stream. Point sources contribute only 1.9% of the sediment load, based on the permitted TSS concentrations and design flows for permitted facilities. Therefore, most of the sediment load is delivered under high flow conditions associated with stormwater runoff.

Potential point source impacts under low flow conditions are not considered significant. The modeled stream flow for Twittys Creek ranged from 0.32 to 93.7 cfs at the mouth of the creek, which scales to 0.22 to 62.6 cfs at the former WestPoint Stevens (permit terminated) outfall. The WestPoint Stevens (permit terminated) outfall represents the most upstream point source location, where stream flow would be least. The 7Q10 low flow condition used to develop permit limits for the WestPoint Stevens (permit terminated) discharge is 0.041 MGD (0.063 cfs). Under this low flow condition, the WestPoint Stevens (permit terminated) effluent comprises 66% of the stream flow when operating at maximum design flow. However, permit discharge limits are designed to protect aquatic life under the 7Q10 low flow condition. As previously noted, the WestPoint Stevens (permit terminated) effluent has been in compliance for all permitted discharge limits since it was upgraded in 2001. The Drakes Branch WWTP has also been in significant compliance with permitted discharge limits, apart from effluent copper concentrations which are being addressed though a compliance schedule.

Since sediment loading occurs throughout the year, primarily due to non-point source runoff, and its impacts on benthic invertebrates are often a function of cumulative

loading, it is appropriate to consider sediment loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 12 year simulation period used in the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and sediment loading by using a daily time-step for water balance calculations. Therefore, the 12 year simulation performed with GWLF adequately captures seasonal variations.

Table 8-1: Recommended Stage 1 TMDL Allocations for Twittys Creek

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	61.0	61.0	0
	Evergreen Forest	31.5	31.5	0
	Mixed Forest	25.9	25.9	0
	Pasture/Hay	354.6	247.6	30
	Row Crop	142.0	99.2	30
	Low Intensity Residential	0.7	0.5	30
	Commercial/Industrial	15.7	11.0	30
	Open Water	0.0	0.0	0
	Woody Wetlands	0.0	0.0	0
	Emergent Herbaceous	0.0	0.0	0
	Transitional	355.0	208.7	41
Instream Erosion	-	80.5	56.2	30
Point Sources	-	20.4	59.6	0
Total		1087.3	741.5	32

8.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Twittys Creek watershed.

The Virginia Department of Forestry (DOF) continues to work with private logging companies in Twittys Creek watershed to implement conservation practices that minimize erosion. More importantly, the public education and outreach conducted by DOF is making a significant difference. DOF has no enforcement abilities, however, through a voluntary program DOF has been able to inspect and insure that logging operations are following the recommended erosion control practices published in DOF manual, (Virginia DOF, 2002).

8.4 Reasonable Assurance for Implementation

8.4.1 Follow-Up Monitoring

VADEQ will continue monitoring stations ATWT003.36, ATWT006.40, and ATWT008.59 in accordance with its biological monitoring program. VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

8.4.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Additionally, Virginia's 1997 Water Quality Monitoring Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU)